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(54) **Method for making composite films.**

(57) Composite film comprising at least one layer of a first plastic polymer and a substrate of a second polymer/first plastic polymer composition is prepared by intimately mixing 15 to 90 wt.% of first plastic polymer and 10 to 85 wt.% of the second polymer, extruding the mixture through a film die while cooling at least one surface of the die outlet at least 10 degrees C below the melting point of the plastic polymer and cooling the film.

METHOD FOR MAKING COMPOSITE FILMS

1 This invention relates to a method for making composite films.

2 Many elastomers are tacky or exhibit cold flow in their
3 green or uncured state. As a consequence, these materials cannot
4 be transported in bulk as free flowing pellets but must be shipped
5 in bales. This practice requires that the ultimate elastomer
6 processor must be equipped to cut up or mill the bales. The
7 necessary equipment is generally large scale, expensive equip-
8 ment. Additionally, the bales cannot be readily preblended with
9 other materials. The necessity for baling results in high
10 handling and shipping costs. In order to facilitate handling and
11 processing of elastomers, it has been considered desirable to
12 produce elastomer pellets. Generally, however, elastomer pellets
13 exhibit "blocking" or cold flow characteristics which result in
14 solidification into a solid mass after a short storage time,
15 especially at warm temperatures.

16 Numerous attempts have been made to formulate elasto-
17 meric pellets which will remain free flowing until they are to be
18 processed. Dusting the elastomeric pellets with inorganic
19 materials, e.g., clay, talc, etc., has been found to extend the
20 time over which the pellets are free flowing. Improved results
21 have been achieved by dusting a coating with selected organic
22 materials such as hydrocarbon waxes (British Patent 901,664) or
23 powdered polyethylenes and polypropylenes (British Patent
24 928,120). However, because of the discontinuity of the dust coat,
25 the coated pellets eventually flow together to form a solid mass.

26 By blending the elastomer with a crystalline type
27 polymer such as polyethylene, polypropylene or copolymers of
28 ethylene and propylene, it has been possible to produce free
29 flowing elastomer containing pellets. However, the elastomer
30 content of the pellet must be less than
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34

1 about 65%. The product is, of course, not suitable for use
2 in all elastomer applications.

3 Another coating approach to the problem has been
4 the coating of elastomer pellets with emulsions containing
5 a tack free coating material. Coating is accomplished
6 either by dipping pellets into the emulsion or spraying the
7 emulsion onto the pellets. In either case the emulsion
8 coating must be dried, and where the emulsion contains a
9 solvent the solvent must be recovered. Drying and solvent
10 recovery requirements result in increased costs.

11 Melt-coating methods for producing free-flowing
12 elastomer pellets have also been suggested. According to
13 U.S. 3,669,772 to Bishop, coating can be accomplished by
14 using a die, similar to wire coating die, into which a
15 strand of rubber to be coated is fed simultaneous with melt
16 coating material. A continuous melt coated strand of
17 rubber issues from the coextrusion die outlet, is cooled in
18 a liquid cooling bath, and is subsequently pelletized.
19 This melt-coating method not only adds significantly to
20 rubber manufacturing costs, but has limitations from the
21 standpoint of efficiently producing large quantities of
22 coated pellets.

23 Pellets of rubber have been coated with various
24 coating materials by heating the rubber pellet to a temper-
25 ature which is higher than the melting point of the coating
26 material, and then contacting the heated pellet with the
27 coating material which is preferably in the form of a fine
28 powder. The heated pellet fluxes the coating material on
29 the surface of the pellet to form a substantially con-
30 tinuous coating. The hot coated pellet is then cooled.

31 A study of bicomponent mixtures has shown that
32 upon extrusion of the mixtures, stratification will occur.
33 See Soulborn, J.H. and Ballman, R.L.; "Stratified Bicom-
34 ponent Flow of Polymer Melts in a Tube", Applied Polymer
35 Science, No.20, 175-189 (1973). The authors attribute
36 stratification to differences in the melt viscosity of the
37 components.

1
2 It has surprisingly been found that a composite film
3 comprising at least one layer of a first plastic polymer and a
4 substrate of a second polymer/first plastic polymer composition
5 can be prepared by intimately mixing about 15 to about 90 wt.% of
6 first plastic polymer and about 10 to about 85 wt.% of the second
7 polymer, extruding the mixture through a film die while cooling at
8 least one surface of the die outlet at least about 10°C below the
9 melting point of the plastic polymer and cooling the film. In a
10 preferred embodiment the first plastic polymer has a semi-
11 crystalline or crystalline melting point which is at least 10°C
12 above the softening or melting point of the second polymer.

13 A sandwich type laminate comprising two outer skins of
14 first plastic polymer enclosing a core comprising a blend of first
15 plastic polymer and second polymer can be prepared by cooling both
16 die outlet surfaces. Where a blown film die is utilized the inner
17 and outer die layers must be cooled to accomplish this end. In a
18 sheet die both the upper and lower die layers are cooled.

19 The accompanying drawings show:
20

21 Figure 1A - Scanning Electron Microscope (SEM) micro-
22 graph of strand-cut pellet sections microtomed at liquid nitrogen
23 temperatures.

24 Figure 1B - SEM micrograph of under-water pelletized
25 pellet sections microtomed at liquid nitrogen temperature.

26 Figure 2A - SEM of surface of strand-cut pellet section
27 microtomed at liquid nitrogen temperatures showing rubber extrac-
28 ted from the surface.

29 Figure 2B - SEM of surface of under-water pelletized
30 pellet section microtomed at liquid nitrogen temperatures showing
31 continuous thermoplastic skin with no rubber extracted.

32 This invention relates to a method for preparing
33 composite films. More particularly, it relates to a method for
34 preparing composite films of a first plastic polymer and a
35 substrate of a second polymer/
36
37

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1 first plastic polymer substrate in a single step extrusion process. The
2 process of this invention may advantageously be utilized to produce
3 sandwich type composite film laminates comprising a core which comprises
4 a blend of the first plastic polymer and second polymer having outer
5 skins comprising the first plastic polymer.

6 By way of illustration the process of this invention is
7 described in terms of preparing a pellet comprising a blend of first
8 plastic polymer and second polymer coated with a skin of first plastic
9 polymer. By reference to this disclosure, however, its applicability to
10 the preparation of composition films will be readily apparent to those
11 skilled in the art.

12 In the practice of this invention an elastomer is blended with
13 a semi crystalline or crystalline plastic material which has a melting
14 point of at least 10°C higher than the softening point of the elastomer,
15 preferably at least about 15°C than the softening point of the elastomer,
16 preferably at least 30°C, more preferably at least 40°C. The elastomer/
17 plastic blend is then extruded through a die in which the die outlet
18 is maintained at least 10°C below the melting point of the plastic in
19 order to develop a temperature gradient across the die from die inlet to
20 die outlet, preferably at least 20°C, more preferably at least about 30°C
21 below the melting point of the plastic.

22 Not wishing to be bound by theory, it is believed that as the
23 melt temperature is reduced across the die, the difference in viscosity
24 between the elastomer and the plastic is increased thereby causing
25 stratification in a manner so as to cause the plastic to be concentrated
26 along the surface of the die orifice while the central core becomes
27 elastomer rich. Shear plays an important part in the stratification
28 process as does the wall effect because of their effect on the velocity
29 profile of the two components of the melt, and hence, the composition
30 differences throughout the melt exiting the die. The melting point of
31 the polymer is a function of shear and pressure, and is higher in the
32 dynamic system of an extruder die than the static melting point of the
33 polymer. As used in the specification and claims, "melting point" will
34 mean the normal static melting point or softening point of the polymer.

35 The elastomer/plastic polymer composition is extruded
36 through a multi-orificed strand die in the aforescribed manner and
37 pelletized either by use of a strand pelletizer or by using a die face

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1 pelletizer. In one embodiment a conventional strand die is modified by
2 having the die outlet plate cored so that it can be water cooled. In a
3 preferred embodiment the die cooling is accomplished by using an
4 underwater pelletizer. Typical of these underwater pelletizers is the
5 mini underwater pelletizer (MUP) manufactured by Gala Industries, Inc.,
6 Eagle Rock, VA.

7 Since the stratification process by which a
8 pellet coated with a skin of plastic is formed requires a
9 finite time the L/D ratio of the die outlet holes is an
10 important criterion in carrying out the process of this
11 invention. The L/D ratio can be about 2 to about 20,
12 preferably about 2.5 to about 12, more preferably about 3
13 to about 10, e.g., about 3.5 to about 8. The die outlets
14 through which strands of elastomer/plastic blends are
15 extruded can be converging tubular outlets which have a
16 larger diameter inlet than outlet. In that event, the L/D
17 ratio is based on an average outlet diameter over the
18 length of the channel.

19 The length of the outlet channel can be about 1
20 inch to about 4 inches, preferably about 1.5 to about 3.5
21 inches, more preferably about 2.0 to about 3.0 inches,
22 e.g., about 2.5 inches. The diameter of the die outlet
23 orifice can be about 0.05 to about 0.200 inches, prefer-
24 ably about 0.075 to about 0.150 inches, e.g., about 0.125
25 inches.

26 A critical parameter in carrying out the pro-
27 cess of this invention is the temperature gradient across
28 the die from the inlet to the outlet. While no particular
29 temperature gradient is required, at some point within the
30 die the melt temperature must be reduced to a temperature
31 which is preferably at about the melting point of the
32 plastic in order to insure that there is a significant
33 difference between the viscosity of the plastic melt and
34 the viscosity of the elastomer melt. It is not essential
35 that the melt temperature of the composition be below that
36 of the plastic melt point. In a preferred embodiment,
37 however, the melt temperature of the composition is

1 reduced to a temperature which is below the melting point
2 of the plastic component. In the preferred method of
3 carrying out the process of this invention, an underwater
4 pelletizer is used and the temperature gradient across the
5 die is created by cooling the face of the die.

6 The maximum temperature differential across the
7 die is achieved by operating at or about the plugging
8 temperature of the system. The "plugging temperature" is
9 that temperature at which some of the die outlet orifices
10 begin to be plugged by solidified polymer. Some plugging
11 of a multi-orifice die can be tolerated up to the point
12 where flow rate is decreased below economical rates.
13 Generally, the outer outlet holes in the die will plug
14 first. A multi-orifice die will have twenty or more outlet
15 holes, e.g., 50-100. It is possible to operate the die at
16 the plugging temperature with as much as about 20-30% of
17 the holes plugged.

18 The plugging temperature is determined by gra-
19 dually cooling the die or die face to the point where
20 outlet hole plugging begins to occur. Operation at the
21 plugging temperature achieves the maximum stratification
22 and plastic skin development in the elastomer pellet.

23 Where an underwater pelletizer is used, the
24 cooling water temperature will be about 20°C to about
25 50°C. The "extruder melt temperature" (the die inlet melt
26 temperature) will be about 160°C to about 250°C and will
27 depend on the elastomer and plastic selected. The appro-
28 priate extruder melt temperature for various plastic/-
29 elastomer compositions is known to those skilled in the
30 extrusion art.

31 The process of this invention is particularly
32 suited to those elastomers which are tacky in their solid
33 state or exhibit cold flow. Illustrative, non-limiting
34 examples of the elastomers to which this invention may be
35 applied are high molecular weight elastomers having a Tg
36 of less than 0°C, e.g. ethylene-propylene rubber (EPR),
37 terpolymers of ethylene, propylene and a non-conjugated

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1 diene (EPDM), natural rubber, polyisobutylene, butyl rub-
2 ber, halogenated butyl rubber, acrylonitrile-butadiene
3 rubber (NBR) and styrene butadiene rubber (SBR).

4 The plastics which may be utilized in the prac-
5 tice of this invention have a crystalline melting point of
6 at least 70°C. Illustrative of those plastic polymers are
7 high density polyethylene (HDPE), low density polyethy-
8 lene (LDPE), polypropylene (PP), LLDPE, syndiotactic po-
9 lybutadiene resin (SBD), polybutene-1 and crystalline co-
10 polymers of ethylene and other alphaolefins. The plastic
11 and elastomer must be insoluble in one another in the melt
12 state.

13 The elastomer-plastic polymer composition of
14 this invention can comprise about 15 to about 90 weight
15 percent plastic polymer, e.g., about 20 to about 80 weight
16 percent. Where the product desired is an elastomeric
17 product the plastic polymer comprises about 15 to about 35
18 weight percent of the composition; preferably about 15 to
19 about 30 weight percent, most preferably about 20 to about
20 28 weight percent, e.g., about 25 wt.%.
21

22 The plastic and polymer may be blended in any
23 conventional manner and fed to an extruder. For example,
24 an elastomer bale can be shredded and blended with plastic
25 polymer powder in a ribbon blender and subsequently fed to
26 an extruder. Preferably a mixing extruder, e.g., twin
27 screw extruder is used for the extrusion to insure com-
28 plete mixing of the elastomer and plastic. The mixture is
29 extruded out of a conventional multi-orificed die in which
30 the die face is maintained at a temperature of at least
31 about 10°C below the melting point of the plastic polymer.
32 Preferably the die face is maintained at a temperature at
33 least about 10°C below the melting point of the plastic
34 polymer; more preferably at least about 20°C; most pre-
35 ferably at least about 30°C below the melting point of the
36 plastic. Of course, in view of the high melt temperature
37 of the polymers the entire die plate cannot be maintain-
ed at a single temperature, and there will be a temperature

1 gradient across the die from its internal inlet surface to
2 its outer face at the outlet of the die.

3 To demonstrate the effectiveness of the instant
4 invention, an elastomer-plastic polymer composition hav-
5 ing the formulation shown in Table I was extruded through
6 a conventional multi-orificed strand die and cooled by
7 passing the polymer strands through a water bath. Sub-
8 sequently, the strands were pelletized. Additionally the
9 same formulation was pelletized using an underwater pel-
10 letizer.

11 The underwater cut pellets had a plastic skin,
12 a lower coefficient of friction and were more free flowing
13 than the conventional strand pelletized material. Table
14 II compares the coefficient of friction of the two pro-
15 ducts, and Table III shows the pressure/strength ratio for
16 the compositions. The pressure/strength ratio is the
17 ratio of the consolidation pressure to yield strength
18 under the shear required to create pellet flow. A higher
19 ratio is indicative of a more free flowing pellet.

TABLE 1

Elastomer/Plastic Composition

22 Elastomer¹: 40% by weight

23 Plastic Polymers

24 HDPE² 16% by weight

25 Polypropylene (3) 44% by weight

26 1. An ethylene propylene copolymer containing 43% ethy-
27 lene, having a glass transition temperature of 55°C,
28 and having a mooney viscosity of 25 (1+8 at 127°C).

29 2. AB 55-100; a 10 melt index HDPE polymer.

30 3. An isotactict polypropylene reactor copolymer of
31 propylene and ethylene having a crystalline melt tem-
32 perature of 160°C.

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TABLE II

Process	Wall Friction Angle (Degrees)	
	Stainless Steel	Aged Carbon Steel
A Conventional strand cut	22	22
B Underwater cut (skin)	13	18

TABLE III

Process	Consolidating Pressure (psi)	Yield Strength (psf)	Pressure/Strength ratio
A	386	135	2.49
B	272	18	15.1

In preparing the underwater die cut pellets of this invention, the MUP was operated with an extruder melt temperature of 408°F, an extruder pressure of 1600 psi and cooling water temperature of 105°F. The extruder output rate was 125 lbs/hr.

It is evident from the above data that pellets made according to the process of this invention are more free flowing than strand pelletized material even where the compositions are identical. Figure 1A and B are SEM micrograph comparisons of the strand formed pellets (Fig. 1A) and the underwater cut pellets (Fig. 1B). The rubber phase of the composition was extracted with hexane. As can be seen from the micrograph of Fig 1B, the product produced according to the process of this invention has a skin which is substantially all plastic polymer while the pelletized strands are essentially of uniform composition throughout.

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1 In order to demonstrate that the skin of the
2 pellets of this invention are substantially all plastic
3 polymer, the pellets were treated with hexane to extract
4 the rubber phase. A comparison of Figures 2A and 2B show
5 that rubber was extracted from the surface of the con-
6 ventional strand pelletized material, whereas substan-
7 tially no rubber was extracted from the skin of the pellets
8 prepared according to the process of this invention.

9 While the invention has been described in terms
10 of a process for manufacturing an elastomer coated pellet
11 having a plastic polymer skin, it will be evident from the
12 foregoing disclosure that the process can be utilized to prepare
13 polymer film comprising a laminate of one polymeric material over
14 another. Alternatively, it may be utilized to prepare a sandwich of
15 one polymer material on each face of a second polymer material.

16 The criteria for the manufacture of such films
17 is that a first polymer must be insoluble in a second
18 polymer in the melt state, and that the polymers have
19 softening or melt points which are separated from one
20 another by at least 10°C; preferably at least about 30°C;
21 more preferably at least about 40°C. The polymer, which
22 is intended to produce the "skin" of the composite, must
23 have the higher melting point.

24 With respect to the description of the inven-
25 tion relating to free flowing pellets, the core of the
26 pellet is generally an elastomer. The second polymer of
27 the film composition need not be an elastomer so long as
28 the foregoing criteria are met.

29 The film may be produced using conventional
30 film forming techniques, e.g., blown, cast or tubular
31 water bath methods. However, in order to form the "skin"
32 on at least one surface of the composite, a die surface
33 must be cooled in the aforescribed manner.

34 A conventional method of preparing blown film
35 utilizing an "A" frame and nip roll provides for cooling
36 of the extruded, blown film using an annular water bath
37 which surrounds the film bubble and cools it. This

1 technique can be modified by cooling the inner die outlet
2 lip either by water cooling the face or by using a water
3 cooled mandrel in extruding the blown film and cooling the
4 mandrel.

5 Similarly a slit die may be used to prepare
6 coated film. If only the upper or lower die outlet lip is
7 cooled a film comprising two layers, the plastic layer and
8 an elastomer or second plastic layer is formed. Where both
9 die lips are cooled, a sandwich is prepared with outer skins
10 of plastic polymer and an inner core of elastomer or second
11 plastic polymer.

12 In another embodiment of the invention, a second
13 plastic polymer may be compounded with chemical blowing
14 agents. Alternatively, a pneumatogen e.g., Freon, may be
15 injected into the extruder melt. The resulting product has
16 a foamed core between two plastic polymer skins.

17 In another embodiment an elastomer is blended
18 with tackifier resins, e.g., terpene resins to form a
19 pressure sensitive or melt adhesive. Only one die outlet
20 lip is cooled. The resulting product is an adhesive coated
21 film of plastic polymer useful as wall or shelf coverings.

22 Where the elastomer/plastic polymer composition
23 has the formulation shown in Table I a sandwich can be
24 prepared having a heat sealable plastic skin and a flexible
25 elastomer core. The product is useful for flexible packag-
26 ing operations, e.g., medical solution bags.

27 In addition to the plastics described above,
28 other polymers, e.g.; thermoplastic polyesters, ionically
29 crosslinked polymers, PVC, etc. can be utilized to prepare
30 the coated films of this invention. The ionically cross-
31 linked polymers included sulfonated EPDM and carboxylic acid polymers
32 of ethylene or carboxylic acid copolymers of styrene.

CLAIMS

1. A process for preparing a composite film comprising at least one layer of a first plastic polymer and a substrate of a second polymer/first plastic polymer composition wherein the plastic polymer has a semicrystalline or crystalline melting point which is at least 10 degrees C higher than the second polymer softening or melting point, the first plastic polymer comprising from 15 to 90 weight percent of the second polymer/first plastic polymer composition, the second polymer and plastic polymer being insoluble in one another, which comprises:

- (a) intimately mixing the second polymer and first plastic polymer;
- (b) extruding the mixture through a film die having a die outlet comprising a first die surface and a second die surface, whilst
- (c) cooling at least one surface of the die outlet to a temperature at least 10 degrees C below the melting point of the plastic polymer; and
- (d) cooling the film so formed.

2. The process according to Claim 1 wherein the first plastic polymer comprises from 15 to 60 weight percent of the second polymer/first plastic polymer mixture.

3. The process according to Claim 2 wherein the first plastic polymer comprises from 15 to 35 weight percent of the second polymer/first plastic polymer mixture.

1 4. The process according to claim 1, 2 or 3
 wherein the second polymer is an elastomeric polymer
 having a Tg of less than 0°C.

5 5. The process according to Claim 4 wherein
 the elastomer comprises EPR, EPDM, NR, SBR, PIB, or
 halobutyl rubber, or mixtures thereof.

 6. The process according to any one of the
 preceding claims wherein the first plastic polymer
 comprises HDPE, LPDE, LLDPE, polypropylene, polybutene-1,
10 a crystalline copolymer of ethylene and an alphaolefin or
 mixtures thereof.

 7. The process according to Claim 5 and 6
 wherein the elastomer comprises EPR or EPDM and the
 plastic polymer comprises a crystalline
15 ethylene-propylene copolymer, HDPE or mixtures thereof.

 8. The process according to Claim 7 wherein
 the elastomer is an ethylene propylene copolymer and the
 plastic polymer is a blend of an HDPE and a crystalline
 copolymer of ethylene and propylene.

20 9. The process according to Claim 8 wherein
 the elastomer/plastic mixture comprises about 40 weight
 percent elastomer based on the elastomer/plastic mixture,
 the HDPE comprises about 16 weight percent of the
 elastomer/plastic mixture and the crystalline ethylene
25 propylene copolymer comprises about 44 weight percent of
 the elastomer/plastic mixture.

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1 10. The process according to Claim 4 or 5
wherein the plastic polymer is sulfonated EPDM ionomer or
poly(ethylene glycol terephthalate).

5 11. The process according to any one of the
preceding claims wherein the second polymer comprises an
elastomer and is combined with a tackifier resin thereby
forming an elastomeric pressure sensitive adhesive
composition.

10 12. The process according to any one of the
preceding claims wherein the die is a blown film die
having an annular outlet bounded by an inner and outer
die lip, only said inner die lip being cooled.

15 13. The process according to any one of claims
1 to 11 wherein both the first and second die surface are
cooled.

 14. A composite film produced by the process
according to any one of claims 1 to 13 when in the form
of wall or shelf covering, or a flexible packaging such
as a medical solution bag.

FIG.1A 1 / 2

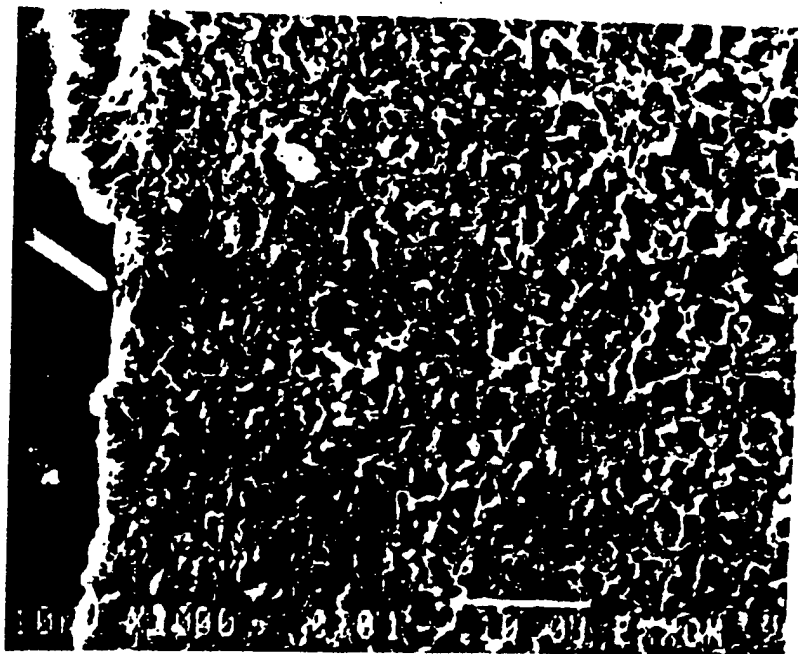


Figure 1A- Scanning Electron Microscope (SEM) micrograph of strand-cut pellet sections microtomed at liquid nitrogen temperatures.

FIG.1B

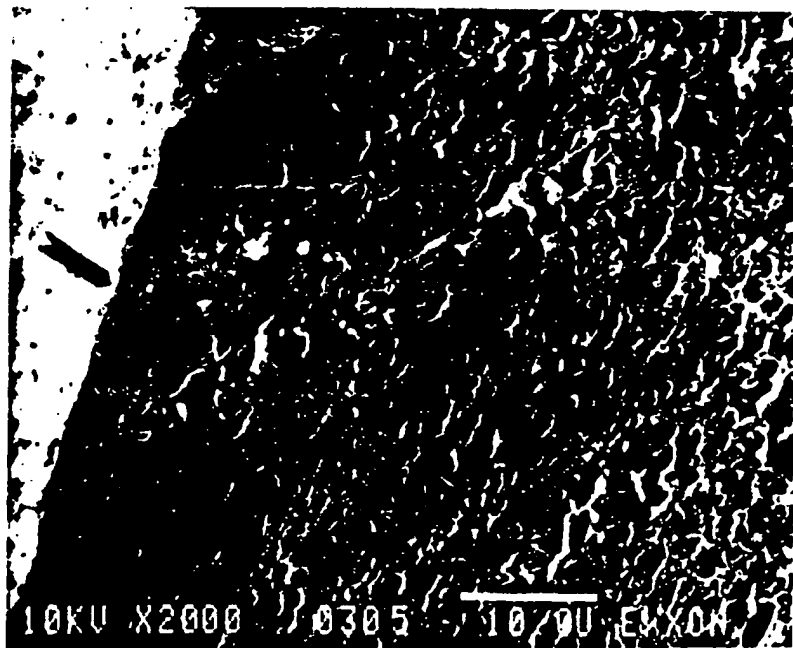


Figure 1B- Scanning Electron Microscope (SEM) micrograph of under-water pellet sections microtomed at liquid nitrogen temperatures.

FIG.2A

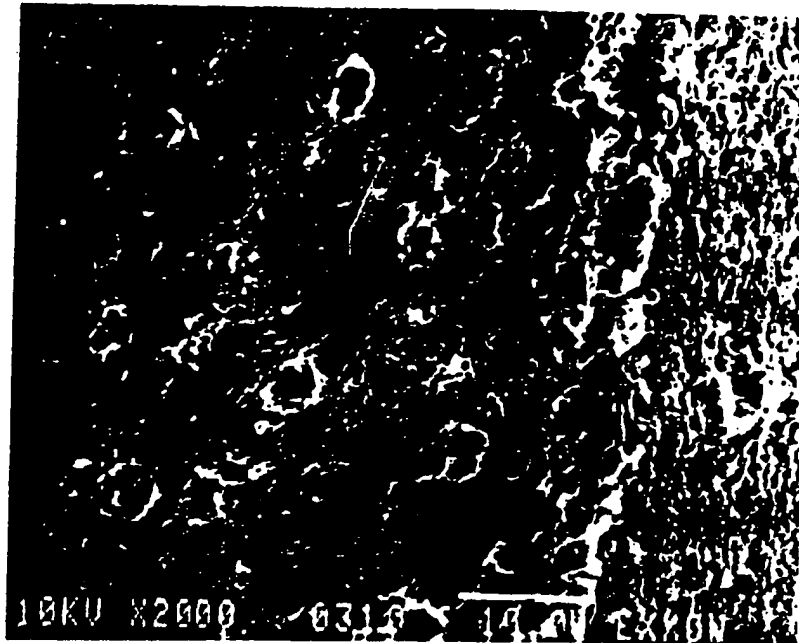


Figure 2A- SEM of surface of strand-cut pellet section microtomed at liquid nitrogen temperatures showing rubber extracted from the surface.

FIG.2B

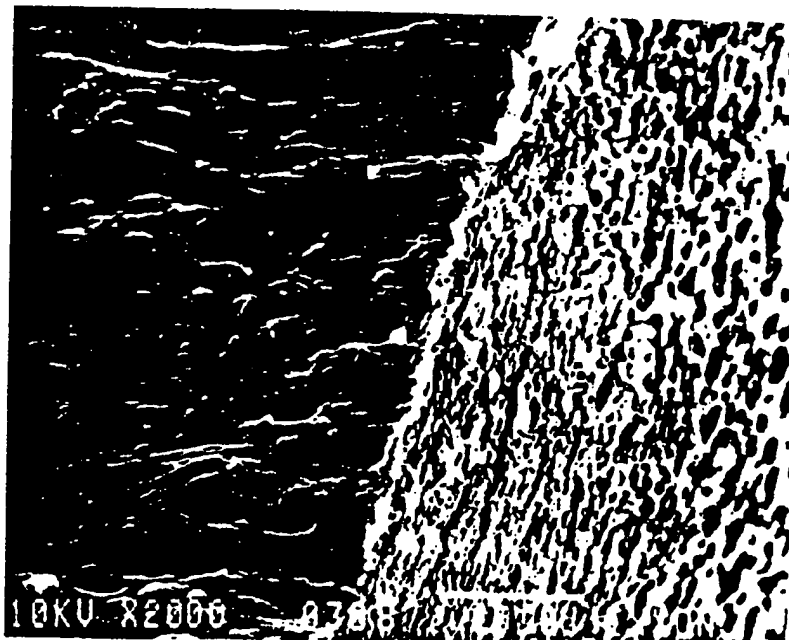


Figure 2B- SEM of surface of under-water pelletized pellet section microtomed at liquid nitrogen temperatures showing continuous thermoplastic skin with no rubber extracted.



European Patent
Office

EUROPEAN SEARCH REPORT

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Application number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 86309833.1
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	EP - A2 - 0 090 554 (E.I.DU PONT DE NEMOURS AND COMPANY) * Page 5, line 14 - page 8, line 33 * --	1-3,6	C 08 J 5/18 B 29 C 47/04 B 29 D 7/01 B 23 B 27/08
A	DE - A - 1 504 331 (W.R.GRACE & CO.) * Totality * --	1-3,6-9	// (B 29 C 47/04 B 29 L 7:00)
A	DE - A - 1 704 561 (LA CELLOPHANE S.A.) * Totality * --	1-3	
A	DE - B - 1 923 852 (ALKOR-WERK) * Totality * ----	12,13	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
			C 08 J B 29 C 47/00 B 92 D B 32 B
Place of search VIENNA		Date of completion of the search 23-03-1987	Examiner WEIGERSTORFER
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons a : member of the same patent family, corresponding document</p>			